
Update on Power Plant and Energy Environmental Issues

Chesapeake Bay Program

The Power Plant Siting Program, precursor to PPRP, was created in 1971 in response to public concern about the proposed Calvert Cliffs Nuclear Power Plant. Calvert Cliffs became the focus of many of the initial environmental studies, including studies of the Chesapeake Bay, conducted by PPRP and the facility's owner, BGE.

During the 1970s and early 1980s, the health of the Chesapeake Bay and its living resources declined significantly because of a variety of factors attributable to humans. Increasing public concern about the state of the Bay led to the establishment of the Chesapeake Bay Program in 1983. Twenty years after the initiation of the Power Plant Siting Program, data from many of the long-term, scientifically rigorous studies conducted at Calvert Cliffs and other power plant sites continue to be used in Bay research. Thus, the motivations and forces that created and sustained PPRP are very similar to those that foster the Chesapeake Bay Program.

Power Plants as Sources of Impact on the Bay

The Chesapeake Bay Program, a cooperative state and federal effort, has identified several environmental factors that contribute significantly to the degradation of the Bay and the decline of its living resources. Key among these factors is high loading of nutrients (phosphorus and nitrogen), which results in excessive production of algae. The excess algae block light from reaching submerged aquatic vegetation and decrease dissolved oxygen levels in deeper portions of the Bay as dead algae decompose. Major sources of nutrients entering the Bay include effluents from sewage treatment plants, runoff from urban and agricultural lands, and deposition of nitrogen from the atmosphere. The introduction of toxics into the Bay also has been one of the Chesapeake Bay Program's major concerns because of the effects of toxics on organisms in all links of the Bay's food chain and the potential human health risk posed by toxics. Primary sources of toxics include industrial discharges and runoff from the Bay's watershed. Some of the toxics in watershed runoff originate from atmospheric deposition.

Over-exploitation of the Bay's fish and shellfish resources and degradation of critical habitats for commercial, recreational, and ecologically important species are also significant concerns for the Chesapeake Bay Program. One important objective of the Program is to remove obstacles to upstream migration of anadromous fish that use Bay tributaries as spawning and nursery areas.

Constructing and operating power plants clearly has the potential to contribute to most of the key environmental issues being addressed within the Chesapeake Bay Program. For example, emissions from power plants may contribute to atmospheric nitrogen loading to the Bay's watersheds. Power plants release a variety of toxics, including mercury, through atmospheric emissions and runoff. Power plants that use Bay water for cooling reduce fish and crab stocks by entraining larvae and impinging juveniles and adults. In addition, hydroelectric plants on the Susquehanna River have been obstacles to upstream migration of anadromous fish into the largest tributary of the Bay. Fish passage facilities at those dams play an essential role in meeting the Chesapeake Bay Program's goal to restore anadromous fish. Most recently, the focus has shifted to the Bay's tributaries to address the sources of adverse effects on the Bay. Many power plants in Maryland are situated on major tributaries, and PPRP's studies at those plants have yielded information that may contribute to developing the Chesapeake Bay Program's tributary management plans.

Relationship of PPRP to Chesapeake Bay Program Activities and Objectives

CEIR-8 described the contributions of past PPRP-sponsored studies to the Chesapeake Bay Program's accomplishments. PPRP continues to support one of the Chesapeake Bay Program's most notable monitoring efforts, the Long-Term Benthic Monitoring Program (LTB). LTB is a major element of the Chesapeake Bay Program's comprehensive effort to monitor the status, trends, and changes in the Bay ecosystem. PPRP continues to provide partial funding for several components of the state's Chesapeake Bay monitoring program.

PPRP recently administered a research project to establish benthic restoration goals for the Bay's tributaries using LTB data and data collected in the companion Virginia benthic monitoring program. LTB benthic data have proven invaluable for tracking changes in the status of the Bay's living resources in response to the Chesapeake Bay Program's enhancement and management efforts.

PPRP's continuing toxics studies augment Chesapeake Bay Program efforts to assess sources, consequences, and means of mitigating the effects of toxics introduced into the Bay. A recently completed PPRP project investigated the contribution of power plants to mercury loadings to Maryland's environment. Mercury is an environmental contaminant of significant public interest, particularly regarding its presence in the tissue of edible fish. Extensive ongoing work, funded by PPRP, is devoted to characterizing atmospheric deposition of trace elements, including organic and inorganic toxics, to the Bay and its watershed. A one-year PPRP field program that monitors loadings of atmospheric trace elements to the Bay is being continued for two additional years under Chesapeake Bay Program funding.

Four additional studies sponsored by PPRP are designed to improve estimates of deposition fluxes of particles. The first focuses on the size distributions of atmospheric particles entering the Bay, and how size changes with different meteorological conditions. The second is a model-based approach for estimating deposition velocities of particles. A third PPRP-sponsored study estimates the extent to which trace elements from atmospheric deposition are transmitted through forested watersheds to Bay tributaries. The fourth study investigates the

feasibility of using trace elements to identify sources of toxic emissions deposited in the Bay watershed. All of these studies will develop means of determining the sources of toxics loadings to the Chesapeake Bay, including power plants, and will help identify potential means of reducing or eliminating those loadings.

PPRP is working closely with MDE to define and evaluate contaminant loadings in the Bay and its tributaries and is assisting MDE in developing toxic discharge criteria for power plants. These efforts will further contribute to identifying the contribution of power plants to toxics loadings to the Bay and appropriate regulatory measures for reducing those loadings as established in the Chesapeake Bay Program's toxics control strategy.

In further support of the Chesapeake Bay Program's efforts to reduce nutrient loading to the Bay, PPRP recently co-funded a study with MDE to evaluate the potential effects of the CAA Amendments of 1990 on NO_x emissions and nitrate deposition to the Chesapeake Bay watershed. That study suggested that aggressively controlling NO_x emissions (going beyond the standard requirements of the CAA) in a region encompassing the District of Columbia and 20 states east of the Mississippi River could significantly reduce atmospheric nitrate deposition to the Bay.

PPRP continues to coordinate its research, monitoring, and assessment efforts with ongoing Chesapeake Bay Program studies and activities to ensure that the contribution of power plants to Bay impacts and means of mitigating for those impacts are identified and addressed efficiently.

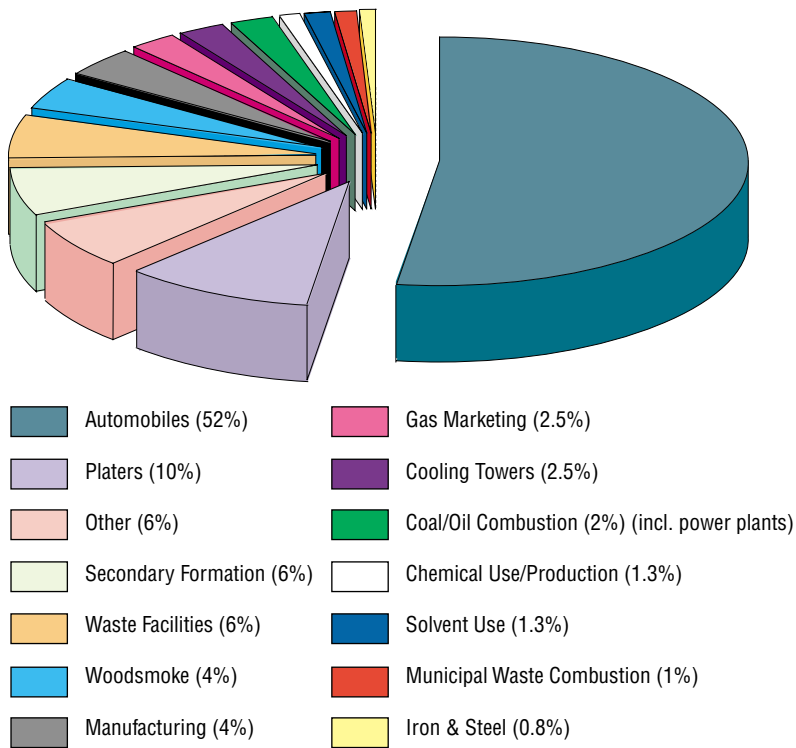
Toxic Substances

Power plants, like other industrial sources, can release toxic chemicals into the air, surface water, and ground water. Toxic substances are chemicals which, if released into the environment in sufficient amounts, have the potential to adversely affect human health or environmental resources. Research in this area is termed "fate and effects" because it looks at how toxic substances are released, where in the environment they end up, and what the consequences of the releases might be for people, plants, and animals. PPRP has sponsored a range of fate and effects research on toxic substances related to power plants.

Toxic Substances in the Air

There is increasing public awareness and concern over the impacts of toxic substances released to the atmosphere, also referred to as **hazardous air pollutants (HAPs)**. The concerns relate to both routine emissions, such as those from automobiles and other fuel combustion, and accidental releases. They relate to carcinogens (pollutants that cause cancer) and non-carcinogens (pollutants that produce detrimental, non-cancerous health effects such as respiratory ailments). Motor vehicles are currently believed to be the major sources of routine toxic emissions in urban areas (see Figure 4-1). Power plants are responsible for most of the coal/oil combustion-based emissions, which comprise 2% of the total HAPs emissions.

Figure 4-1
Sources of Hazardous Air Pollutants



People can be affected by toxic substances through the air they breathe — **direct pathway** — and through the food they eat — **indirect pathway**. Toxic substances deposited in farming areas or in watersheds that support fish can end up in food. Such indirect pathways can be complex. For example, toxic emissions to the atmosphere can be carried to the soil by rain, then absorbed by the roots of garden fruits and vegetables, eventually contaminating the produce that reaches our dinner tables.

The State of Maryland, as well as the federal government, are in the process of evaluating the effects of toxic emissions. These efforts examine uncertainty in the current understanding of exposure pathways and potential risks. A margin of safety is usually used in formulating regulations to protect people, and worst case scenarios are often assumed. For example, air regulations for toxic emissions are fre-

quently developed to protect a hypothetical person exposed throughout his or her lifetime, outdoors, at the location of maximum exposure from a source of toxic substances. This is an unrealistic situation that errs on the side of overestimating risk. As our understanding of the processes involved improves, estimates of potential risks will continue to become more realistic.

At present, emissions of toxic substances from power plants are not regulated specifically either by the state or federal government, although many air toxics are regulated indirectly through controls on particulate matter emissions. Utilities and non-utility developers have also addressed air toxic emissions when seeking approval for new power plants in Maryland. Licensees have used MDE's exposure thresholds, applicable to industrial sources, to assess potential toxic effects to humans. In addition, the State has requested licensees, where warranted, to assess toxic effects to locally grown crops and other vegetation. Because of the uncertainties in the health impacts of power plants, the CAA Amendments of 1990 mandate studies of the effects of air toxic emissions from utility boilers, and a special study of the effects of mercury emissions. The results of these studies eventually may be used to formulate federal regulations for controlling toxic emissions from power plants.

Atmospheric Emissions of Toxic Substances

There are many unanswered questions about the health effects of routine power plant toxic emissions. Two of the unanswered questions are related to indirect pathways of toxic exposure in general and to mercury emissions from coal

burning in particular. Although the concern most frequently addressed is breathing contaminants in the atmosphere, current health risk studies indicate that, in rural settings, health risks from indirect pathways of exposure (deposition of contaminants by rain and incorporation into the food chain) also may be a potential concern.

Several studies of the health risks associated with utility emissions of toxic substances are underway currently. The U.S. EPA, the U.S. Department of Energy (DOE), and the Electric Power Research Institute (EPRI) are focusing on assessing risks from breathing contaminants and on obtaining more accurate emissions data to improve estimates of human health effects.

PPRP has conducted several investigations of toxic emissions from power plants. Preliminary results of PPRP's investigations suggest that metals are the toxic substances of greatest concern for health effects, but that predicted health effects due to emissions of metals are small for the proposed plants that PPRP has investigated. For example, a state-of-the-art, multipathway risk assessment was performed in conjunction with the licensing of PEPCO's Station H power plant in Montgomery County. This study indicated that health effects of toxic emissions from the proposed facility would be lower than any Food and Drug Administration health concerns, and would result primarily from consumption of food.

In response to local residents' concerns, PPRP recently assessed the potential effects on residents and local ecology of the Panda-Brandywine cogeneration facility proposed for construction in Prince George's County. Toxic emissions to the atmosphere are associated with occasional combustion of fuel oil as an emergency back-up for gas, and with use of sewage treatment plant effluent as makeup water in the cooling tower. It was important to consider the source of cooling water because people and plants might be exposed to chemicals carried in cooling tower drift emissions. PPRP performed both a human health and an ecological risk assessment to characterize the potential for adverse effects from exposure to ambient concentrations or from deposition of toxics. A wide variety of chemicals that might be released and several possible routes of exposure to people and vegetation were considered. The analyses indicated that any environmental concentrations of chemicals resulting from proposed power plant operation would be close to background concentrations and safe for residents, their crops, and the surrounding natural vegetation.

PPRP is continuing its investigations and reviewing other studies to determine the potential effects of power plant toxic emissions on the residents of Maryland. PPRP is focusing its investigations on potential toxic emissions from the types of fuels burned in Maryland power plants, the effectiveness of rain in depositing contamination in the air onto soils and ponds close to power plants, and the toxicological effects of the pollutants.

Mercury

The concentration of mercury in the global atmosphere has been increasing at least since the industrial revolution. On a global basis, about one-half of the mercury released to the atmosphere through human activities can be attributed to the burning of fossil fuels — primarily coal, which contains trace amounts of the element. Mercury emitted to the atmosphere enters surface waters in rainwater and possibly through dry deposition. In many lakes in the U.S. and Canada, atmospheric deposition is believed to be the primary source of contamination

because no other input has been identified. Mercury accumulates in fish and can cause toxic effects on the nervous systems of people and wildlife that eat contaminated fish.

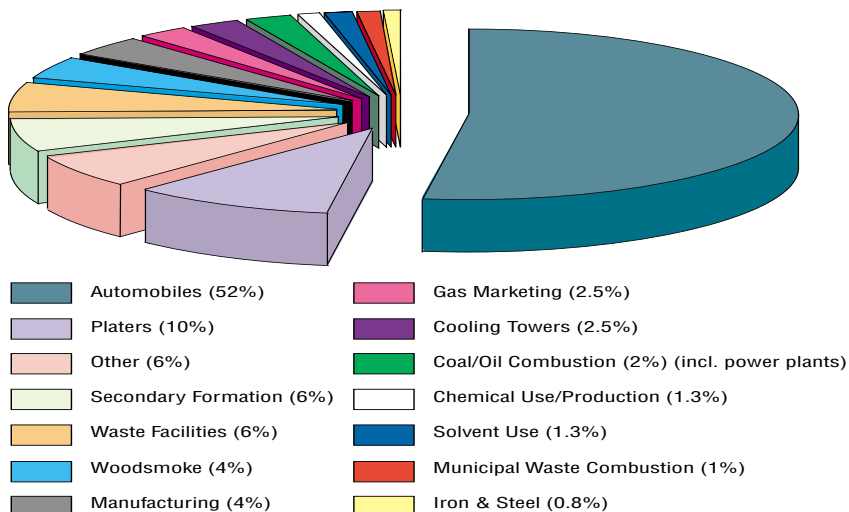
At present, 24 states have issued health advisories limiting consumption of fish because of high levels of mercury. The U.S. Food and Drug Administration (FDA) has an action level for mercury in fish tissues, which has been adopted by Maryland. As yet, no mercury concentrations above the FDA action level have been observed in fish from Maryland waters. In 1993, the U.S. EPA provided states with new guidance for issuing advisories on consuming mercury contaminated fish and new methods for determining safe levels of mercury for groups with different sensitivity and different rates of fish consumption.

There are many unanswered questions about the environmental fate and effects of mercury. They include questions about how much mercury is released during combustion, the chemical and physical properties of the released mercury, the transformations that occur after it is released to the environment, and the toxicological effects on people and wildlife. In response to the growing concern, the CAA Amendments of 1990 specifically require the U.S. EPA to identify mercury emission sources, evaluate the contributions of power plants and municipal incinerators, identify control technologies, and evaluate the toxicological effects of eating mercury-contaminated fish. EPRI, in coordination with the U.S. EPA, is sponsoring studies on the environmental fate and effects of mercury and is attempting to resolve difficulties in the sampling and analysis of the element.

PPRP also initiated its own studies to determine whether mercury is a significant toxic chemical issue in Maryland, and to analyze atmospheric mercury emissions

in Maryland for 1990, the latest year for which data were available. Three major sources contributed more than 90% of mercury released to the atmosphere: municipal incinerators burning batteries and other household products containing mercury, latex paints containing mercury, and coal-fired power plants (Figure 4-2). These studies indicate that, although coal-fired power plants contribute to mercury emissions, the resulting concentrations are not high enough to adversely affect humans or other organisms. At present, the importance of local atmospheric sources relative to out-of-state sources is not known.

**Figure 4-1
Sources of Hazardous Air Pollutants**



Accidental Releases of Toxic Substances

There is always some possibility that hazardous substances stored and used at power plants and other industrial facilities could be released into the environ-

ment accidentally. Electric utilities must use several hazardous substances to operate their power plants, and, in most cases, there are no nonhazardous substitutes for these compounds. For example, ammonia and sulfur trioxide can be used in air pollution control systems. Chlorine is used routinely at power plant intakes to treat water and reduce biofouling. Hydrogen is used as a cooling medium for generators. Halon may be used in fire suppression systems designed to protect electrical and computer components. Although manufacture of polychlorinated biphenyls (PCBs) was discontinued in the United States in 1976, there are still some transformers in use today that contain the material. Atmospheric discharge of PCBs resulting from transformer fires or explosions can present risks to an exposed population. Accidental release of natural gas and liquefied petroleum gas poses risks of fire and explosion.

Regulations regarding accidental releases of toxic or hazardous substances into the environment have been promulgated under provisions of both Superfund and the CAA. Each of these are briefly summarized below.

- Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), also known as the Emergency Planning and Community Right-to-Know Act of 1986, provides a means for informing the public of the existence, quantities, and releases of hazardous substances. This law directs states, communities, and industry to work together to plan for chemical accidents, develop inventories of hazardous substances, track toxic chemical releases, and provide public access to information on hazardous substances. SARA Title III legislation was the direct result of the release of toxic chemicals in 1984 and 1985 in Bhopal, India, and Institute, West Virginia. Utilities have to comply with the law, but are currently exempt from certain portions.
- Under the CAA Amendments of 1990, the U.S. EPA has proposed regulations requiring risk management plans for potential releases of 77 acutely toxic substances and 63 flammable substances. Sources of toxic emissions, including power plants, that produce, process, handle, or store any listed substance in amounts exceeding the established threshold quantities will be required to prepare risk management plans. These plans must include an evaluation of worst-case off-site effects of accidental releases of the substances, and must detail the measures the facility will take to prevent and respond to an accidental release.

PPRP is presently evaluating the potential for accidental releases of listed substances from Maryland power plants. This investigation will also review current and proposed state and federal regulations to ensure that they adequately protect communities from the risks involved in power generation, in a cost-effective manner.

Toxic Chemicals in Water

Chlorine

Many Maryland power plants must draw in and use large quantities of river or Bay water to cool steam condenser tubing as part of the power generation process. The utilities frequently need to use chemical **biocides** to keep the condenser tubes clean and to keep aquatic organisms from clogging power plant systems. Chlorine is the most commonly used biocide, and trace amounts of it are released in the cooling water discharge.

In the 1970s and 1980s, concern over discharges of chlorine led the U.S. EPA and states to regulate the concentration and duration of chlorinated discharge. Chlorine is highly toxic to aquatic life, particularly larval fish. Although chlorine is still the most commonly used biocide in power plants across the United States, a number of facilities recently have conducted trials with alternative biocides, such as sodium bromide, and are exploring new techniques to minimize the amounts of chlorine used.

Metals

In addition to chlorine and other components of biocides, power plants can also discharge trace amounts of metals into the environment. The sources of the metals are wastewaters from cooling operations, boiler cleaning, ash generation, and disposal. Runoff from coal piles can also release toxic substances into the environment. Under the 1987 Clean Water Act (CWA) Amendments, the U.S. EPA developed lists of waterways that have been impacted by toxic chemicals, as well as discharges to these waterways. Ten power plants across the U.S. were included on the CWA's list of toxic dischargers.

The power plants were listed primarily because metal concentrations in their water discharges exceeded established levels. Two Maryland power plants — Brandon Shores and Vienna — were included on the list because concentrations of copper in their discharge water exceeded state standards. Control strategies are being developed to reduce these concentrations.

PPRP has recently examined the contribution of power plant discharges to copper levels in surface waters. It has been recognized that condenser tubing in power plant systems corrodes and releases copper into the environment. Copper/nickel tubing is used at 10 of the 13 Maryland power plants examined in the study. An alternative to copper/nickel tubing is tubing made of titanium, which is much more resistant to corrosion than copper and so should release smaller amounts of metals into the environment. The settlement of a lawsuit between MDE and a group of industries addresses the issue of pollutant discharges in excess of standards due to corrosion and erosion of condenser tubes. MDE's proposed regulations now provide for a one-time allowance for these discharges if the discharger commits to replacing the tubes with noncorrosive materials within five years. It is likely that new power plants will use all titanium in the future.

Coal Piles and Ash

Toxic substances can be released into the environment by leaching from coal storage piles or from ash landfills. Toxics can also enter the environment from historical releases of substances no longer used, such as PCBs. PPRP has monitored potential impacts of toxic releases from ash storage facilities in a number of projects.

In the mid-1980s, PPRP sponsored research on the effects that arsenic and selenium released from ash landfills could have on striped bass. These metals may enter aquatic systems as airborne fly ash or in runoff from coal and ash piles. This study found that selenium levels near discharge points may be high enough to cause adverse effects from long-term exposure.

PPRP also investigated past reports of declines in the numbers of yellow perch in Zekiah Swamp Run in Charles County, which is near PEPCO's Faulkner Ash Storage Facility. Monitoring studies indicated that ground water collected from wells near the facility was contaminated with heavy metals, but that contamination was limited to an area within about 1,500 feet from the landfill. The chemical monitoring studies did not indicate surface water contamination of Zekiah Swamp; however, other tests conducted in Zekiah Swamp indicated that yellow perch larvae had difficulty surviving in areas of the swamp within and outside of the range of possible influence of the Faulkner facility. The study concluded that many factors are responsible for the poor larval survival and that the ash facility did not contribute to the observed mortalities.

Global Climate Change

The **greenhouse effect** is a naturally occurring phenomenon in which clouds and certain gases found in relatively minute amounts in the atmosphere trap heat emitted by the earth's sun-warmed surface, and warm the atmosphere near the ground. In recent years, there has been a realization that the release of greenhouse gases from human activity, including burning of fossil fuels, could be enhancing the greenhouse effect. The potential for dramatic climate change (global warming) due to emissions of greenhouse gases such as carbon dioxide (CO₂) has spurred intense scientific investigation and prompted response on a world-wide scale. Because fossil fuel combustion by utilities and others is a significant source of CO₂ emissions, efforts to reduce CO₂ could affect utility operations.

Reasons for Concern

Based on estimates from complex mathematical computer models, many prominent researchers believe that global warming can be expected as atmospheric concentrations of greenhouse gases rise. In addition to CO₂, there are several other important greenhouse gases, including chlorofluorocarbons (CFCs), methane (CH₄), and nitrous oxide (N₂O). These other gases are more effective at trapping the earth's infrared energy, or have greater **radiative forcing effect**, than CO₂ (Table 4-1). For example, methane molecule for molecule, absorbs 25 times more long-wave radiation than CO₂. Nevertheless, CO₂ has been the main focus of greenhouse gas reduction policies because it is significantly more abundant in the atmosphere (see Table 4-1).

CO₂ also contributed almost as much to the increase in absorption of infrared energy during the 1980s as all the other greenhouse gases combined (Figure 4-3). A current estimate suggests that without controls, the concentration of all

CFCs and Ozone Depletion

The stratospheric ozone layer helps to shield the Earth from the sun's harmful ultraviolet radiation. In the mid-1980s, scientists discovered that portions of the protective ozone layer above Antarctica were destroyed each year, resulting in a phenomenon known as the "Ozone Hole." This layer of ozone has been thinning slowly since the late 1970s. Over the past few years, the depletion of ozone has reached record proportions. The extent of stratospheric ozone depletion observed in 1994 was similar to the record-setting values of 1992 and 1993. Scientists expect that ozone depletion will peak around 1998. Then, ozone levels will gradually rebound as a result of international agreements to reduce the use of ozone-depleting chemicals.

Chlorofluorocarbons (CFCs) and halons, two types of inert gases, have been clearly implicated in the depletion of stratospheric ozone. After being released, CFCs are long-lived in the atmosphere, eventually reaching the stratosphere to contribute to the destruction of the ozone layer. Worldwide, CFCs have been used primarily for refrigeration, foam production, and aerosol propellants. Their use as an aerosol propellant has been banned in the United States since the 1970s. In response to the findings that CFCs were destroying stratospheric ozone, 35 countries, including the United States, signed the 1987 Montreal Protocol, committing to reduce production of CFCs and halon gases drastically. In a 1992 revision to the Montreal Protocol, the countries agreed to phase out CFC production by the end of 1995. Recently, scientists have reported that the rapid increase in CFC concentrations has fallen off substantially.

Electric utilities are very minor contributors of atmospheric CFC emissions. However, domestic and commercial use of less effective and less energy-efficient CFC substitutes could increase the demand for electricity. This increased demand could potentially increase the emissions of other greenhouse gases, such as CO₂.

Table 4-1
Concentrations of the Major Greenhouse Gases, Their
Growth Rates, and Radiative Forcing Effects (Relative to
that for CO₂)

Greenhouse Gas	Pre-Industrial Concentrations	1990 Concentrations	Annual Growth Rate	Radiative Forcing Effect
CO ₂	280.00 ppmv	353.00 ppmv	0.5%	1
CH ₄	0.80 ppmv	1.72 ppmv	0.9%	25
N ₂ O	290.00 ppbv	310.00 ppbv	0.25%	200
CFC-11	0.00	0.28 ppbv	4.0%	10,000
CFC-12	0.00	0.48 ppbv	4.0%	10,000

ppmv = parts per million by volume
 ppbv = parts per billion by volume

greenhouse gases in the atmosphere will be equivalent to a doubling of the preindustrial level of CO₂ by the middle of the next century.

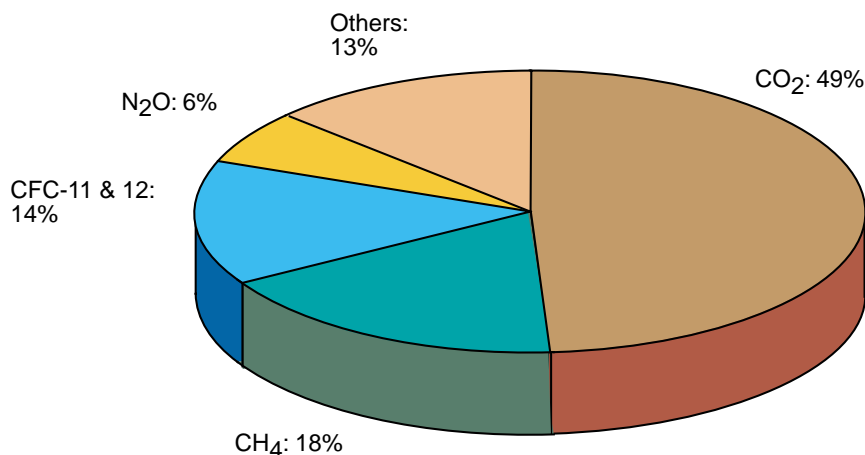
The Intergovernmental Panel on Climate Change (IPCC) originally reported in 1990 that without limits on greenhouse gas emissions, the earth's temperature could warm about 2°F by 2025 and 5.5°F by 2100. In a 1994 update, the IPCC found no new evidence to contradict its findings, and thus reaffirmed its conclusions from the 1990 assessment.

Studies of the global temperature record of the past 100 years indicate an increase of about 0.7°C or 1.2°F (see Figure 4-4). Most experts feel that this warming trend is not conclusive evidence of greenhouse warming because the magnitude of uncertainty concerning this observation masks the true trend. Some researchers

have found the warming observed over the past few decades to be primarily a result of an increase in minimum (nighttime) temperature, while the maximum (daytime) temperature has remained fairly steady. Most experts believe that if there is a real warming trend, it will become apparent within the next 10 to 15 years.

Several plausible effects may be observed, especially in Maryland, during the next century if a substantial warming trend develops. Sea-level rise could adversely affect significant

Figure 4-3
The Contribution to Increased Absorption of Infrared Energy
by Greenhouse Gases During the 1980s

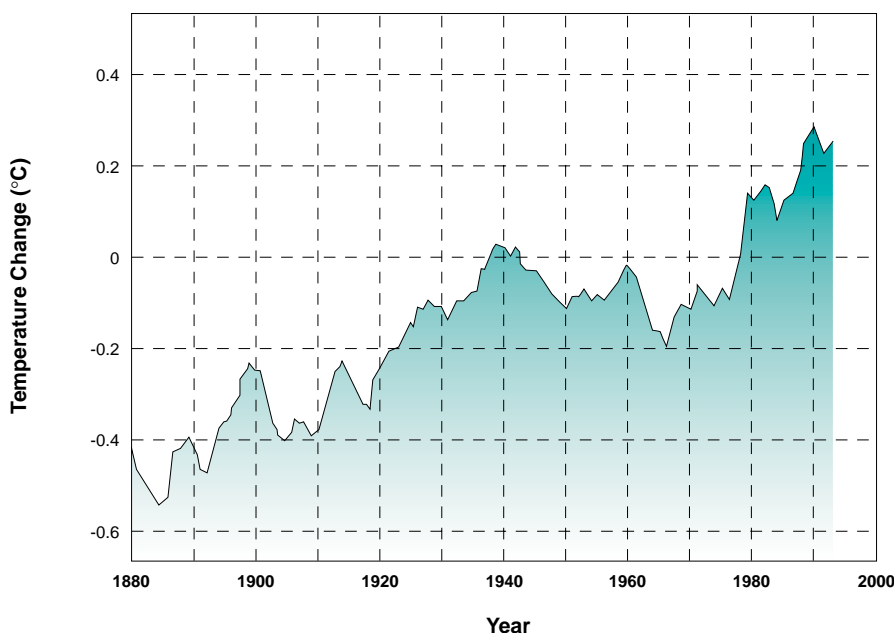


portions of Maryland's Chesapeake Bay wetlands in the next century. Hotter and drier summers with accompanying stagnant weather conditions could worsen Maryland's ozone air pollution problem. Hotter summers also could increase electricity demand in Maryland, as well as in the entire northeast region.

Major questions exist regarding the reality, magnitude, and timing of potential greenhouse-induced climatic effects. These questions are generated by the uncertainties in the greenhouse gas emissions data and atmospheric loading estimates, and the global climate prediction models. Adding to the uncertainties in model

predictions is a recent finding that the cooling effect of sulfur emissions, not accounted for in recent models, may have offset a significant part of the greenhouse warming in the northern hemisphere during the past several decades.

Figure 4-4
Global Average Surface Air Temperature Change
(5-Year Running Mean)



CO₂ as a Greenhouse Gas

Without CO₂ in the atmosphere, life as we know it would not exist on this planet. The natural atmospheric level of CO₂ is the reason why the Earth's temperature averages about 59°F globally instead of about 0°F.

CO₂ is emitted by natural and human sources. CO₂ from human sources is generally believed to be the prime contributor to CO₂ buildup in the atmosphere. Ice core samples from Antarctica and Greenland and direct atmospheric CO₂ measurements made in Hawaii since 1958 indicate that CO₂ levels have been increasing since about the time of the Industrial Revolution. These increases have been attributed to emissions from industrial, utility, and transportation-related sources. The oceans and plants act as CO₂ sinks, removing approximately half of the CO₂ emissions from human sources from the atmosphere. Deforestation increases atmospheric CO₂ by removing a natural sink for CO₂ emissions.

Additionally, human activities have resulted in increased emissions of other more potent greenhouse gases, such as CH₄, N₂O, and CFCs. CO₂ is about 100 times more abundant than the other gases combined; however, because of the recent rapid growth in emissions of these more potent greenhouse gases, the relative importance of CO₂ is somewhat reduced. CO₂ levels are thought to be increasing at a rate of about 0.5% per year (see Table 4-1).

The 1992 Earth Summit

World leaders from over 160 nations met for 12 days in June 1992 in Rio de Janeiro, Brazil, at the United Nations' Conference on the Environment and Development. This Earth Summit was convened to discuss pressing global environmental issues. Discussions focused on two major areas: biodiversity, or the protection of plants, animals, and natural resources; and the control of CO₂ emissions, those emissions primarily responsible for global warming.

The Framework Convention on Global Climate Change, more informally referred to as the Global Warming Treaty, was signed by almost all of the countries in attendance, including the United States. However, for the treaty to officially take effect, it needed to be ratified by 50 countries; the U.S. ratified the agreement in October 1992. The Framework Convention on Climate Change entered into force on 21 December 1993, when it was ratified by the fiftieth nation. This agreement is now binding on all parties to the Convention that had previously signed the accord. The treaty states that the ultimate aim of the ratifying nations is to return to their 1990 emission levels of CO₂, but no timetable is mentioned for reaching such levels. The only binding language in the treaty requires each ratifying nation to issue detailed action plans for stabilizing greenhouse gas emissions. The first meeting of the parties to the Convention was scheduled in late March 1995. The Clinton Administration has developed the Climate Change Action Plan as the United States global warming strategy in response to the requirements of the Convention.

The Utility CO₂ Contribution

The primary manmade CO₂ emission sources are fossil fuel combustion, and biomass burning and decay. Combustion of fossil fuels accounts for most of the CO₂ emissions. On a per-energy-unit basis, coal burning generates the most CO₂, and natural gas burning generates the least. In the United States, the utility industry accounts for roughly 35% of fossil fuel-derived CO₂ emissions (Figure 4-5). The United States contributes approximately 25% of the worldwide fossil fuel-derived CO₂ emissions, the most of any country; therefore, utilities in the United States account for about 8% of the worldwide fossil fuel-derived CO₂ emissions.

Recent Governmental Responses

The federal government recently has taken steps to reduce the United States' greenhouse gas emissions directly, especially CO₂, through the Climate Change Action Plan (CCAP). In addition, greenhouse gas emissions should be reduced indirectly through the Energy Policy Act of 1992. These two programs, as well as policies Maryland has enacted that should help to reduce greenhouse gas emissions, are discussed in this section.

Energy Policy Act of 1992

Congress enacted the Energy Policy Act of 1992 to enhance competition in the electric power industry and to improve efficiency in energy use. The results should indirectly help to reduce emissions of the most important greenhouse gas, CO₂. The Act is considered to be a supplement to existing state

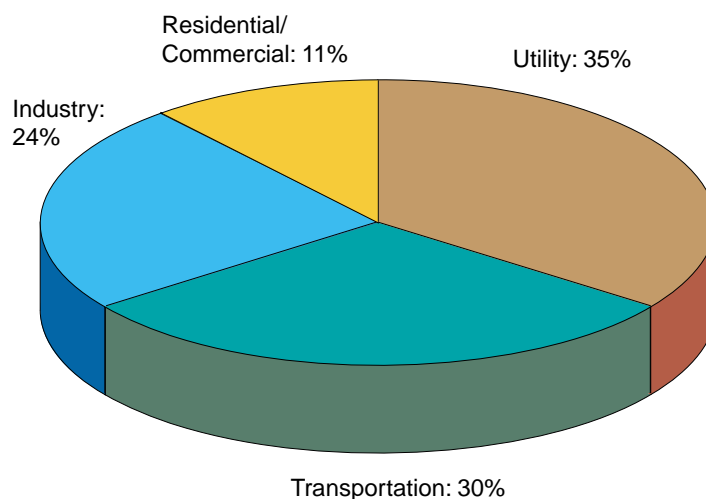
policies regarding energy planning. Through the use of tax incentives, the Act endeavors to make renewable sources of energy, such as wind and solar power, more cost-competitive with traditional fossil fuel sources.

Climate Change Action Plan

The goal of the CCAP, made public in October 1993, is to return greenhouse gas (mainly CO₂) emissions to 1990 levels by the year 2000. This greenhouse gas emission reduction strategy is a response to the Framework Convention on Climate Change agreed upon by attending nations at the 1992 Earth Summit. The CCAP proposes adopting, expanding, or reinforcing innovative and successful greenhouse gas emissions reduction programs, such that the reductions can occur quickly enough to meet the year 2000 goal. The use of renewable energy is encouraged through increased funding, and utilization of incentives contained in the Energy Policy Act of 1992.

The *Climate Challenge* program is one example of the partnerships created through the CCAP. This voluntary program partners DOE with a multitude of electric utility companies to study and develop cost-effective ways to reduce,

Figure 4-5
Relative Contributions of Manmade Fossil Fuel
CO₂ Sources in the U.S.



avoid, or sequester (absorb) greenhouse gas emissions, while considering the potential ramifications to ratepayers. Representatives from DOE and the power industry signed a Memorandum of Understanding on 20 April 1994 that establishes the framework for the *Climate Challenge* program. Overall, the utilities providing 80% of the total electricity generated in the U.S. have signed on to participate in the program.

The Maryland utilities that are participating in the *Climate Challenge* program include BGE, Delmarva Power, PE, and PEPCO. PEPCO has made a commitment with DOE to reduce its greenhouse gas emissions to below 1990 levels by the year 2000. The company plans to achieve this reduction primarily through conservation programs, but they have also included programs involving electric vehicles and other electrotechnologies, and the use of renewable energy. BGE has also committed to reducing its greenhouse gas emissions by 2000 and plans to achieve reductions primarily through supply-side management programs. Furthermore, BGE participates in several programs aimed at reducing greenhouse gas emissions through demand-side energy management, the advance of cleaner alternatively fueled vehicles, forest management, and investments in new electrotechnologies.

State Initiatives

Many states have adopted legislation in recent years to respond to the global warming issue. These responses mainly have taken the form of programs to study greenhouse gas emissions and energy use, and to recommend possible courses of future action. In addition, numerous states have developed programs to increase efficiency in energy use; these projects indirectly decrease net greenhouse gas emissions by reducing CO₂ emissions from various sectors.

AES's Greenhouse Gas Offset Program

In the mid-1980s, Applied Energy Services (AES) initiated a corporate policy of social responsibility with regards to global warming. AES's goal is to preserve coal and natural gas as fuel options at its non-utility generating facilities, while mitigating the effects on global climate that burning such fuels may cause. As part of this effort, AES investigated the least-cost ways to reduce its CO₂ emissions. They found that tree planting could provide an economical and effective solution for mitigating CO₂ emissions from its newly built power plants.

The idea is that by planting trees, enough CO₂ will be absorbed by the trees that it will "offset" the emissions from the power plants. Preventing deforestation can also conserve carbon, which is stored by trees and released when the trees are cut down and burned. Moreover, forest conservation can be supplemented by additional tree plantings as a longer term offset project.

AES began its voluntary CO₂ mitigation measures in the late 1980s through tree planting and land preservation programs in Guatemala, Paraguay, Peru, Ecuador, and Bolivia. It is estimated that through these projects about 45 million trees will be planted and over one million acres of forest will be protected from deforestation. As a result, these efforts will prevent roughly 100 million tons of CO₂ from being released to the atmosphere. AES's associated cost for these efforts is about \$7 million, which is funded mostly through endowments.

The AES Warrior Run power plant is under construction in Cumberland, Maryland, and is scheduled to go on line in 1999. Potential programs addressing social responsibility are usually made once a plant is operational. Thus, no decision has been made yet regarding potential conservation or mitigation projects associated with Warrior Run.

In Maryland, the PSC Integrated Resource Planning (IRP) group endeavors to provide the same consideration to conservation programs (demand side) as to new electricity generation, distribution, and transmission projects (supply side). Utility conservation and energy efficiency programs are formulated and implemented through collaborative arrangements that include the PSC, utilities, DNR, and conservation groups.

Maryland is actively involved in the effort to reduce, through indirect means, CO₂ emissions to the atmosphere. Maryland has developed a State Strategic Energy Plan that makes recommendations for energy efficiency programs involving state government, industry, commercial, and residential projects. The Governor approved the plan in late 1993, and five of the recommendations were put on the "fast track" for implementation.

National Parks and Forests Impacts

Current Adverse Impacts

Utilities in Maryland and surrounding states in recent years have had to address the effects of their new power plant emissions on the following federal areas: Shenandoah National Park in Virginia, Brigantine National Wildlife Refuge in New Jersey, Dolly Sods Wilderness in West Virginia, and Otter Creek Wilderness in West Virginia (both Dolly Sods and Otter Creek are within the Monongahela National Forest) (see Figure 3-7). These areas are referred to as Prevention of Significant Deterioration (PSD) Class I areas. Each Class I area has its own Air Quality Related Values (AQRVs), special attributes of a Class I area that may be adversely affected by deterioration of air quality. AQRVs include visibility, odor, flora, fauna, and geological resources,

archaeological, historical, and other cultural resources, and soil and water resources unique to that site.

Once AQRVs have been established at a Class I area, the Federal Land Manager must determine whether or not the AQRVs are being adversely affected. The criteria for determining whether or not an AQRV is being adversely affected are: 1) diminishment of the national significance of the area, 2) impairment of the quality of the visitor experience, or 3) impairment of the structure and functioning of ecosystems. In September 1990, the Federal Land Manager declared that AQRVs at Shenandoah were being adversely affected. The National Park Service (NPS) has noted the following concerns with regards to Shenandoah:

- *Visibility is impaired by anthropogenic pollution more than 90% of the time; the average reduction from the natural visual range (150 kilometers) is approximately 60%.*
- *Ambient SO₂ levels are in the range known to have contributed to the absence of *Ramalina americana* (lichen) in Canada.*
- *Sulfur loadings at Shenandoah are greater than background levels and are within the range known to cause morphological changes in some species of lichens.*
- *Shenandoah National Park streams continue to acidify over time.*
- *Foliar injury and significant growth and yield reductions in sensitive species results from ozone concentrations less than the National Ambient Air Quality Standard.*

Recent Power Plant Assessments

As a result of concerns over Shenandoah AQRVs, all new power plants recently undergoing PSD review in Virginia have been subject to considerable scrutiny by the NPS. For example, a cogeneration project proposed by Patowmack Power Partners, Inc., for Loudoun County, Virginia, was the focus of extensive and in-depth evaluations of impacts to the AQRVs at Shenandoah. None of the recently permitted power plants in Virginia have been shown to have any adverse impact at Shenandoah. The Federal Land Manager has agreed with these conclusions.

In Maryland, Applied Energy Services, Inc. (AES), as part of its PSD permit application for the coal-burning Warrior Run power plant in Cumberland, assessed potential impacts to the AQRVs at Shenandoah, Dolly Sods Wilderness, and the Otter Creek Wilderness. AES determined that since insignificant amounts of SO₂ would reach Shenandoah, no adverse impact to the AQRVs at the Park will occur. For the two wilderness areas, AES used a new screening approach developed by the Forest Service which allows it to determine potential impacts of new emissions sources on AQRVs for the Class I areas in question. This analysis indicated that only minimal effects on terrestrial and aquatic ecosystems would be realized. Furthermore, the visibility analyses conducted by AES showed no adverse impact. The NPS and the Forest Service agreed with the results of these Class I AQRV analyses.

A PSD permit was recently issued for Delmarva Power's proposed new coal-burning Dorchester power plant near Vienna, Maryland. Delmarva Power examined SO₂ effects at the Brigantine National Wildlife Refuge, 160 km away. Delmarva Power found that the SO₂ levels predicted to occur at Brigantine were below the PSD Class I significance levels; therefore, impacts to AQRVs are not anticipated. Also, using conservative U.S. EPA-approved modeling methodologies, Delmarva Power showed no adverse visibility impact at Brigantine. The U.S. EPA Region III did not dispute these findings.

Interagency Workgroup on Air Quality Modeling

The Interagency Workgroup on Air Quality Modeling (IWAQM), consisting of representatives from the U.S. EPA and the agencies responsible for managing the wilderness and national park resources, was formed to provide a focus for developing technically sound, regional air quality models for regulatory assessments of air pollutant source impacts at Federal Class I areas. These assessments include effects on air quality related values (AQRVs), as well as compliance with air quality standards. To this end, the IWAQM developed a multi-year work plan which is to be implemented in three phases. Phase 1, completed in October 1992, consisted of a review of U.S. EPA guidance and issuance of recommendations for "off-the-shelf" modeling techniques to meet the immediate need of the permitting community. During Phase 2, the IWAQM will augment Phase 1 with a review of other available models and make a recommendation of the most appropriate modeling techniques. In Phase 3, the IWAQM will add more advanced modeling techniques to its consideration and recommend a more permanent modeling solution, probably representing a greater level of scientific and computer hardware sophistication.

Ramifications for Utilities

In recent years, the NPS and Forest Service have been requiring more extensive and in-depth AQRV impact evaluations for new source permit applications in the region around Shenandoah, as well as other Class I areas in the Northeast United States. In addition, the NPS has established emissions offset requirements for certain new construction projects. The NPS requires an applicant to obtain an emissions decrease (or offset) at another facility equal to the emissions increase associated with the proposed project if an applicant's impact on AQRVs is above the NPS significance level. Also, the NPS requires a demonstration of a net AQRV benefit to the Class I area.

Overall, as the NPS has increased its scrutiny of impact analyses for new source permit applications, the amount of time required to obtain a permit has increased. Recently, this review process has taken as long as three years because of increased requirements.

Western Maryland Coal Mining Issues

Maryland Coal Industry

The coal mining industry is a significant factor in Western Maryland's economy. Located on the extreme eastern edge of the Appalachian Basin, Garrett and Allegany Counties account for all of Maryland's coal production. In 1993, roughly 3.4 million tons of coal were mined in Maryland, and an average of 441 miners were employed in the industry. Approximately 21 active mines were operating in Maryland as of 1993. Only four of the operating mines are deep mines; the remainder are strip/surface mines. Deep-mined coal accounts for roughly 75% of the coal mined in Maryland, with virtually all (99%) of the deep-mined coal being produced from the Mettiki mine in Garrett County. According to the latest available data, Maryland has roughly 664 million tons of underground coal reserves and approximately 86 million tons of surface coal reserves.

In 1993, Virginia Power's Mount Storm plant purchased nearly half of the coal produced in Maryland. The other major utility purchasers were PEPCO, which purchased 25% of the total Maryland coal production in 1993, and Monongahela Power Company, which purchased 15%. Relatively small amounts were purchased by PE, Delmarva Power, and New England Power Company. The balance of the coal produced was either exported, sold to other mining companies for blending with other coals, or used by industrial sources.

The potential use of Maryland coal, as with any coal, is influenced by its characteristics. Maryland coal is generally described as having a low to medium volatile content, a medium sulfur content, and relatively high ash content and ash fusion temperature. From a technical perspective, two characteristics of Maryland coal limit its use in existing Maryland utility boilers: relatively high ash fusion temperature and the low volatile content.

Coal-fired boilers that employ a wet ash removal system (wet bottom boilers) require coal with low ash fusion temperatures to maintain the ash as a liquid. Because most Maryland coals have relatively high ash fusion temperatures, they are not suitable for use in wet bottom boilers. For example, BGE's C.P. Crane units are wet bottom cyclone boilers, and could not burn Maryland coal.

Coals with low volatile content, such as most Maryland coal, are more difficult to ignite and require specially designed combustion systems to sustain combustion. In addition, a high, stable burning rate is required to use low volatile coal; variations in burning due to load shifts would likely result in operational problems. For example, the design and operation of BGE's H.A. Wagner Unit 4 and PEPCO's coal-fired Dickerson coal units preclude the use of Maryland coal.

In addition to technical feasibility, environmental regulations and transportation issues also constrain the use of Maryland coal. From an environmental perspective, the sulfur content of Maryland coal limits its use in some Maryland utility boilers such as BGE's Brandon Shores and H.A. Wagner plants. Economic and transportation issues also impact the use of Maryland coal. For example, although Western Maryland is well served by existing rail lines, transporting Maryland coal to utilities in the eastern part of the state is more expensive and complicated than transporting Pennsylvania-mined coal to these destinations due to the need to contract with both CSX and Conrail.

Environmental Issues

Sulfur Dioxide Emissions

The medium sulfur content of Maryland coal precludes its use at some coal boilers without extensive emissions control. Maryland coal at BGE's Brandon Shores and H.A. Wagner units could not meet currently imposed federal and state SO₂ emissions requirements without post-combustion controls. The sulfur content of Maryland coal will also constrain its future use because of SO₂ limitations in 1995 (Phase I) and 2000 (Phase II) required by Title IV of the 1990 CAA Amendments. The sulfur content of most Maryland coal is being reduced by state-of-the-art cleaning methods. These methods will result in CAA compliance for Phase I, but cleaning alone will not meet Phase II SO₂ standards.

The SO₂ reductions mandated by the CAA could significantly affect the use of Maryland coal at PEPCO's Chalk Point and Morgantown boilers. To comply with these requirements under Phase I, PEPCO plans to use an optimum mix of low-sulfur coal and natural gas co-firing at Chalk Point and to burn low-sulfur coal, possibly with some oil firing, at Morgantown. Although Maryland coal is capable of meeting the Phase I SO₂ standards, if a significant amount of natural gas is used in the Chalk Point boilers, the amount of Maryland coal used in these boilers would be reduced. PEPCO is currently evaluating options to achieve Phase II standards. Because the sulfur content of Maryland coal will not meet Phase II standards without expensive air emissions control such as scrubbing, the use of Maryland coal at Chalk Point and Morgantown could be discontinued altogether. Some coal companies have begun selling SO₂ emission allowances along with their coal contracts, which could improve the marketability of Maryland coal in Phase II.

Acid Mine Drainage

Water pollution associated with mining is a significant environmental issue. Mine drainage water comes from surface water, from rain or runoff, or from ground water aquifers that are disturbed by the coal mining operation. Major water pollutants include suspended solids, dissolved solids, sulfates, and acidity. Of these, acidity or acid mine drainage is a significant concern to Maryland coal miners.

Drainage from mines (and from areas of land affected by mining) becomes acidic due the leaching of oxidized pyrites (a form of inorganic sulfur combined with iron). The major means of controlling wastewater acidity is through lime neutralization. The neutralized mine drainage water can then be sent to a holding pond for reuse or discharge.

Besides lime neutralization, another potential technique for treating acid drainage involves the use of limestone and ash by-product from fluidized bed combustion (FBC) boilers or from scrubber systems. Currently, much of the by-product material produced around the country is landfilled. There are no commercial power plants in Maryland that use FBC technology or are equipped with scrubbers, although Maryland does receive by-product from other states for landfilling. The quantity of these wastes will likely become more abundant in the future as a result of more stringent air pollution control requirements.

DOE, the University of Kentucky Center for Applied Energy Research, and Addington Resources, Inc. are currently evaluating the feasibility of using dry FGD wastes as backfill in the tunnels left by highwall mines. In Maryland, one coal supplier is already using FBC by-products from an AES plant in Connecticut to backfill mined areas. AES intends to dispose of the by-product from its proposed Warrior Run FBC plant in the same way.